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PARTIAL EXPLORATION PLAN
ENVIRONMENTAL BASELINE
DATA COLLECTION
AND MONITORING ELEMENT
(REVISED BIOLOGY RESOURCES PROGRAM)

FEDERAL OIL SHALE PROTOTYPE LEASING PROGRAM
TRACTS U-a AND U-b, UTAH

WHITE RIVER SHALE PROJECT

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COLORADO, INC.
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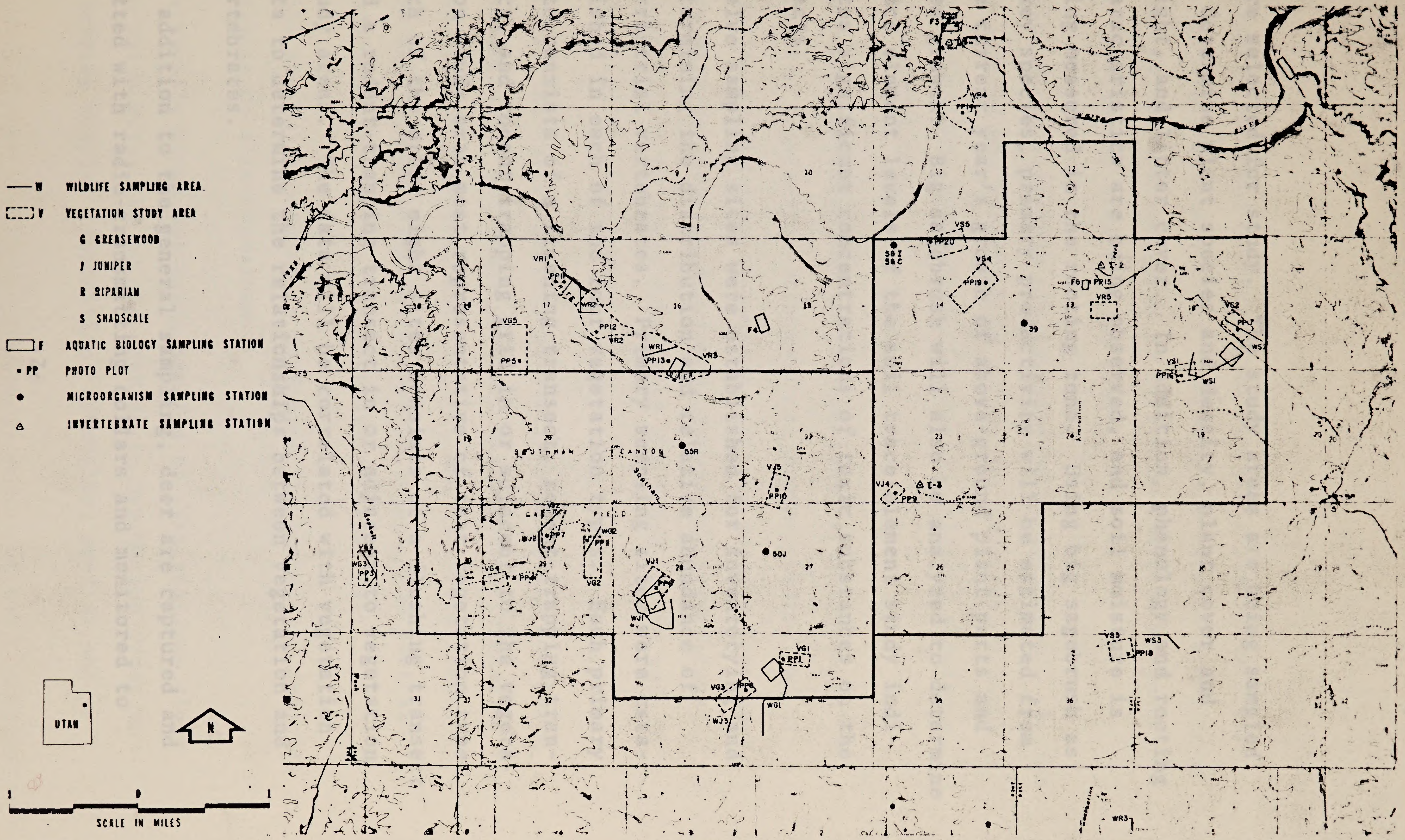
C. BIOLOGICAL RESOURCES

The baseline data collection program was designed as a means of collecting data concerning the biological resources and the operative aspects of the ecosystem of Tracts U-a and U-b and the area contained within a perimeter 1 mi around the boundaries of the tracts, from here on referred to as the project area. The baseline data will be used to predict and evaluate the effects of oil shale development within the tracts, to develop plans for revegetation and fish and wildlife management, and to monitor the effects of development.

Most of the techniques used in the study are those of the International Biological Program (IBP) Desert Biome Study (Balph 1973). The IBP computer program will be used to process, analyze, and summarize most of the field data. Although the sampling sites and the sampling procedures are interrelated, for clarity the methodology is presented separately for each element. The sampling sites are shown on Figure C-1.

1. OVERVIEW

Four vegetation types were identified in the project area--shadscale-sagebrush, greasewood-sagebrush, juniper-sagebrush, and riparian. The vegetation was mapped from aerial photographs and ground surveys. Within each vegetation type, five areas that reflected the variation within that type



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BIOLOGICAL RESOURCE SAMPLING LOCATIONS

FIGURE C-1

were selected for study. The study areas are being sampled to determine plant species and density, plant cover and height, and litter cover. In addition, phenology and rooting characteristics are being observed, and soil moisture is being measured in the rooting zone. Using big sagebrush as a key species, primary productivity will be estimated from the current year's growth of above-ground plant parts and stem growth. Big sagebrush will also be analyzed to determine trace element levels if the soil trace-element study indicates significant concentrations of toxic substances on the tracts.

Twelve sampling sites were established for inventorying and determining the distribution and relative abundance of terrestrial vertebrates. Primary sampling sites were established in each of the four vegetation types. Each primary site consists of a flushing transect, rodent-trapping transect, and rodent-trapping grid in or adjacent to the vegetation study area most representative of that vegetation type. Each of the other eight sites consists of a flushing transect and a rodent-trapping transect in or adjacent to vegetation study areas. The data will be correlated with vegetation data to determine the relationships between vegetation and vertebrates.

In addition to the general sampling, deer are captured and fitted with radio-transmitting collars and monitored to

determine seasonal migration and use areas. When they can be captured, mountain lions, bobcats, and coyotes are fitted with collars and monitored to determine seasonal movements and territorial limits (home range).

During winter, raptors are inventoried by helicopter. Eyries are located and inspected in spring for information about nest locations, numbers of fledglings, relative abundance, and seasonal use.

The number of sheep and cattle and their activities are estimated from aerial observations, ground counts, and inspection of BLM grazing records. Tissue samples from deer mice will be analyzed for trace-elements if significant accumulations of toxic substances are found in the soil or vegetation on the tracts.

Terrestrial invertebrates, primarily arthropods, are being inventoried to determine species, distributions, relative abundance of some dominant species, and interrelationships with other elements of the ecosystem, e.g., food habits, predation, parasitism, and habitat requirements.

Soils are being sampled to determine the number and seasonal activity of microorganisms.

The aquatic biota are being sampled at five stations along the White River and at one station in Evacuation Creek to determine species composition, diversity, spatial and

temporal distribution, relative abundance, and productivity. Sampling is concentrated on filamentous algae, periphyton, plankton, macroinvertebrates, and fish.

The aquatic stations were situated near the hydrology stations to correlate hydrological and biological data. The stations were also placed to sample the different flow characteristics of the river, e.g., pools, riffles, eddies, etc.

Biotic and abiotic data will be correlated to determine the structure and function of the ecology of the tracts and to define specifically some of the significant and critical interrelations between ecosystem components.

2. VEGETATION

a. Objectives

The objectives of the vegetation portion of the baseline program are as follows:

(1) Identification of the major vegetation types on Tracts U-a and U-b and location of their general distribution

(2) Determination of the structure and composition of each vegetation type, which includes species, height, and density.

(3) Recording of stages of plant development (phenology).

(4) Assessment of the productivity of each vegetation type to determine production of annual and perennial species and determination of the productivity potential of the site.

(5) Use of sufficiently accurate and repeatable sampling procedures and adequate sampling intensity to provide data on major plant species suitable for statistical comparisons with future data.

b. Methodology

Vegetation Mapping

On the basis of discussions with Bureau of Land Management personnel responsible for grazing management of the tracts and adjacent areas, published information of the region, aerial photographs, and extensive ground reconnaissance, vegetation types were mapped on an aerial mosaic photograph. Four main vegetation types were identified and delineated--sagebrush/greasewood, juniper, shadscale, and riparian. The classification of vegetation types followed the methods of Stoddart et al. (1938) and Harper et al. (1974).

Community Structure and Composition

In each of the four vegetation types, five study areas were selected to reflect the average expression of each vegetation type. Twenty 4-m^2 plots were randomly selected in each study area.

Vegetation is studied each spring to estimate the characteristics of species maturing in June (mostly annual species) and associated shrubs and other perennials. Vegetation is studied again each fall to estimate the parameters of species maturing in late summer and associated species, mostly perennials.

During each sampling period, four plant attributes--species, height, cover, and density--are determined for each plot by two-person sampling teams. Information recorded on data sheets includes (1) vegetation type, (2) study area, (3) plot number, (4) date, (5) species, (6) number of individuals contained within the plot, (7) height of species in cm, and (8) the area in cm^2 within the plot covered by each species.

The list of species found on the tracts is compiled from specimens collected throughout the growing season, since not all species occur at a given sampling time. Collected plant specimens are dried in plant presses, mounted on herbarium paper, labelled, and stored at the Intermountain Herbarium at Logan, Utah, in accordance with the methodology of Harrington (1964). Species are determined according to Welsh (1957), Holmgren (1962), Anderson and Holmgren (1969), and Harrington (1964).

The methods of sampling and analysis are similar to those used in the IBP Desert Biome (Desert Biome 1973) study at

Curlew Valey in northwestern Utah. This program can be used for the tracts because the vegetation of the validation site at Curlew Valley is a similar salt-desert shrub type, although Curlew Valley contains a more uniform topography and vegetation.

Field-plot data are analyzed statistically to determine means, 90 percent confidence interval (C.I.) about the means, and the necessary sample size (number of plots) required to estimate within 25 percent of the true mean with a 90 percent statistical probability for each attribute measured for each species. After the fourth sampling period, data from all periods will be pooled to provide an overall description of vegetation within appropriate levels of statistical adequacy. Cover data may be calculated in terms of all plots sampled (100 per vegetation type) to provide average values for the vegetation type.

Plant density is calculated by determining the number of plants per unit area. The data will include the number of plots in which the various species occur and the average number of plants in the 4-m^2 plots.

Phenological Characteristics

In six key periods of the year, observations of plant development are recorded by species from each of five 3-m^2 plots. Plots are located in vegetation study areas. Plant development is recorded according to a computer-based code that

consists of 22 arbitrary attributes such as flowering, budding, leafing, insect damage, senescence, and grazing pressure. The data are transferred to key-punch computer cards, and the computer is used to obtain average conditions of species for each date observed.

Productivity

Productivity, community structure, and composition are sampled at the same time and in the same plots. In the fall sampling periods, productivity of perennial species is measured. Productivity of annual species is measured during the spring sampling period.

During the fall sampling period, the current year's growth contained within a 100-cm^2 area of each shrub and tree species is clipped and placed in a bag labeled with the (1) vegetation type, (2) study area, (3) plot number, (4) species, and (5) date. The contents of each bag are dried and weighed in the laboratory. The dry weight of each species is multiplied by the species' cover value ($cm^2/4m^2$) of the same plot and divided by 100 to obtain productivity expressed as grams per 4-m^2 plot (dry weight).

During the spring sampling period, a 0.5-m^2 quadrat is placed randomly within the 4-m^2 plots. All annual grasses and forbs contained within the 0.5-m^2 quadrat are clipped at ground level, sorted by catagory (i.e., grass or forb) and placed in bags labeled with the (1) vegetation type,

(2) study area, (3) plot number, (4) category, and (5) date. The contents of each bag are dried and weighed in the laboratory. The dry weight of each species is multiplied by 8 to obtain productivity expressed as grams per 4-m^2 plot (dry weight). In the first year's sampling periods (fall 1974 and spring 1975), the average productivity values for each species or category were reported as an estimate of the general productivity of each vegetation type, bare ground excluded. In other words of dry weights a species in each 4-m^2 plot in the vegetation type are summed and divided by the number of plots in the vegetation type in which that species occurred. The second year's data (fall 1975 and spring 1976) will be reported as an estimate of the general productivity of each vegetation type, bare ground included. In other words dry weights of a species in each 4-m^2 plot in the vegetation type are summed and divided by the total number of plots in the vegetation type (100 plots). In this approach it is assumed that the five sampling sites for each vegetation type and the 20 randomly chosen 4-m^2 plots within each of five sites are representative of the vegetation type, bare ground included.

c. Ancillary Investigations

Root Growth

In the root-growth study, dominant species selected as representative samples are uprooted, and the roots are measured in centimeters for penetration depth and lateral extension.

Vegetation in Relation to Soil Salinity

To identify some general relationships between salinity levels and vegetation, a cursory sampling of soils is conducted in the vicinity of Evacuation Creek. Soil samples from eight locations adjacent to and on the various levels above the creek are collected and returned to the laboratory for evaluation. The species growing around each soil sample are identified and enumerated.

Vegetation Trace Element Study

A study of trace elements in sagebrush will be conducted only if the results of the soil trace element analysis indicate toxic concentrations of trace elements on the project area. The trace elements to be analyzed are arsenic, antimony, cadmium, flourine as flouride, mercury, and selenium.

Sagebrush was chosen for analysis because it occurs in all four vegetation types and is an important food source for wildlife, particularly in winter, when annuals are not present and smaller shrubs are buried in snow. The current

year's leaf and stem growth of sagebrush would be analyzed by atomic absorbtion or spark-source mass spectrometry. Six samples would be collected in each vegetation type for statistical comparisons.

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3. TERRESTRIAL VERTEBRATES

a. Objectives

The objectives of the terrestrial vertebrate study are as follows:

1. a list of all terrestrial vertebrate species
2. a determination of the distribution of each species
3. an estimate of the population density of each species
4. a record of the migratory activity of migrant species
5. an understanding of the relationships between terrestrial vertebrates and other components of the ecosystem

b. Methodology

Three types of sampling programs were developed to meet these objectives:

(1) a scheduled program in which specified areas are sampled at specific times to meet the first through fifth objectives, especially the second, third, and fourth

(2) an opportunistic sampling program to meet the first and fifth objectives, particularly with respect to amphibians, reptiles, and bats

(3) special studies of some economically important and/or sensitive vertebrates, including deer, geese, predators, raptors, beaver, livestock, and coyotes.

Scheduled Program

The scheduled sampling program is conducted at 12 sampling sites (Figure C-1). There are four primary sampling sites on the tracts, one in each major vegetation type. The sites were designated primary greasewood (WG-1), primary juniper (WJ-1), primary shadscale (WS-1), and primary riparian (WR-1). Each primary site was situated in an area considered by project botanists as most representative of the vegetation type. Because they are the most important sites, they are sampled more intensively than the others.

Three secondary sampling sites were established in similar vegetation at a different location within the tracts to augment the primary sampling sites. The secondary sites were designated secondary greasewood (WG-2), secondary juniper (WJ-2), and secondary shadscale (WS-2). The lack of sufficient accessible areas of riparian vegetation precluded establishing a secondary riparian site.

Five off-tract sampling sites were established to sample areas adjacent to the tracts. The off-tract sites were designated off-tract greasewood (WG-3), off-tract juniper (WJ-3), off-tract shadscale (WS-3), off-tract riparian (WR-2), and riparian-greasewood (WR-3).

Two major sampling techniques are used to determine the numbers and kinds of terrestrial vertebrates on the sites: Flushing transects are used to sample diurnal mammals, birds, amphibians, and reptiles; and live-trapping is used to sample nocturnal rodents. A 1.0-km flushing transect was established at each primary sampling site except at the primary riparian. A 0.5-km transect is positioned on the primary riparian site and on each of the secondary sites and off-tract sites. All transects are positioned to obtain a representative sample of the vertebrates within the vegetation types. Biologists walk the transects and record the animal species seen and the distance in meters of each animal from the transect line at first sighting. Species identification follows Behle and Perry (1975); Durrant (1952); Burt and Grossenheider (1964); Murie (1975); Peterson (1961); Robbins et al. (1966); Stebbins (1966), and AOU (1957).

The flushing-transect data for each species is first grouped into class intervals of distances from the transect line. The class intervals (meters) used for diurnal mammals and birds are 0-5, 6-10, 11-15, 16-20, 21-25, 26-30, 31-40,

41-50, 51-75, 76-100, and >100. Those used for amphibians and reptiles are 0-1, 2, 3, 4, 5, and >5. These data are then analyzed to determine the number of animals per hectare (ha). Gross et al. (1975) discuss in detail the mathematical and statistical basis for the method used in the analysis of flushing-transect data.

Variation for the statistical analysis is generated by daily variation in the number of animals seen along the transects. Confidence intervals are given for species dense enough to make such a probability statement meaningful. Statements regarding the reliability of the density figures apply to the precision of the estimate at the time and place the data are collected.

A rodent live-trapping transect is established at each sampling site to provide an index to rodent density. The transect consists of 2 parallel lines of 12 trap stations each, with 15 m between the lines and 15 m between the trapping stations. The trapping transects straddle the flushing transects. A single Sherman live trap (7.6 cm x 7.6 cm x 25.4 cm) baited with rolled oats is used at each trap station. Upon capture the animals are identified and released. Information recorded on the field sheet includes (1) date, (2) sampling site, (3) sampling day, (4) species, (5) sex, (6) age, and (7) capture number. The data is reduced and presented for each species as the number of captures per 100 trap nights.

The flushing and trapping transect sampling program is conducted on 6 consecutive days at each of the 12 sampling sites. On the first day, the rodent traps are set on the trapping transects within 1 hour of sunset. On the second day, five procedures are conducted: (1) the flushing transects are walked for birds between sunrise and 2 hours after sunrise; (2) rodent traps are checked and closed between 1 hour and 4 hours after sunrise; (3) the flushing transects are walked for amphibians and reptiles at any time between 4 hours after sunrise and 4 hours before sunset; (4) the flushing transects are walked for mammals between 2 hours before sunset and just before dark; and (5) the rodent traps are reset within 1 hour of sunset. From the third day to the sixth day, these procedures are conducted daily, except that the traps are gathered on the sixth day.

The time of year and the weather may alter the schedule of the sampling program. The procedures are not conducted during rain exceeding a light drizzle or wind of more than 15 km per hour. The flushing transects for diurnal mammals and birds are walked in December, February, April, June, August, and October; and the flushing transects for amphibians and reptiles are walked in April, June, August, and October. Cold weather in April and October may prevent adequate sampling.

The live-trapping transects for nocturnal rodents are operated in April, June, August, and October. Trapping may be suspended in April, and October if cold weather causes high mortality.

A rodent live-trapping grid is established at each primary sampling site. The grid on the greasewood, juniper, and shadscale sites consists of 12 rows of trap stations and 12 stations per row (144 trap stations) with 15 m between traps in a row and 15 m between rows. The grid at the riparian site consists of 6 rows of trap stations and 12 trap stations per row (72 trap stations). A single Sherman live trap measuring 7.6 cm x 7.6 cm x 25.4 cm and baited with rolled oats is used at each trap station. Upon capture, the animals are identified, toe-clipped, and released. The following information is recorded on field-data sheets for each capture: (1) date, (2) sampling site, (3) sampling day, (4) species, (5) sex, (6) age, (7) animal condition, (8) animal identification number, (9) trap number, and (10) capture number (see Table C-1 for a completed raw data sheet). The live trapping grids are operated for five consecutive days in August of each year.

The trapping grid data are transferred to the Desert Biome Program's coding form No. 139 and are key punched on computer cards that are verified with the field data sheets. The data are processed with the Small Mammal Density and Home

ODENTS SITE: Greasewood WG-1 OBSERVER: CVG + TWS MO.: 8 YR.: 75

AY	SPECIES	AGE	SEX	TOE CLIP	TRAP #	CAP. #	COMMENTS
1	Desert Wood Rat	A	M	0001	014	1	
	↓	A	M	0002	074	1	
2	Desert Wood Rat	A	M	0002	006	2	
	↓	A	M	0001	033	2	
3	Desert Woodrat	A	M	0002	029	3	
	↓	A	M	0001	036	3	
4	Desert Woodrat	A	M	0002	020	4	
	↓	A	M	0001	036	4	TORPOR
5	Desert Woodrat	A	M	0002	007	5	
	↓	A	M	0001	033	5	

TABLE C-1

Rodent Live Trapping Grid Data Sheet

Range Computer Program developed by Kim Marshall and available from the Desert Biome Program, Utah State University, Logan. The Jennrich and Turner (1969) method of determining home range is used to analyze the trapping data. Density is estimated with the Schnabel (1938) technique as presented by Overton (1965). Robert Anderson (Balph 1973) discusses the details of the type of analysis used.

The yearly variation in the size and the dispersion of terrestrial vertebrate populations will prevent the pooling of data for the annual report. Thus, in 1976 the data will be presented in a fashion similar to that of 1975. The final report will include the data from both years as well as a discussion of the differences between years.

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Opportunistic Programs

Amphibians and Reptiles: Although there is no standardized procedure for collecting amphibians, there are certain methods that are better than others for collecting the maximum number of organisms per man hour.

The best time for observing amphibians is during or after spring rainstorms, because they require water for successful breeding and are therefore usually more active during or after rains. After rainstorms roads in and around the project area will be searched in the evenings when many

reptiles and amphibians are most active (Stebbins 1966). When reptiles or amphibians are sighted they are captured, identified, and released (Stebbins 1966). Springs, seeps, and pools are sampled periodically during summer for egg clusters, larvae, and ripe adults.

A .22 caliber revolver and shot shells will be used in a lizard-removal program to be conducted in early summer 1976 on a 1.0-hectare (ha) plot in each vegetation type if populations cannot be adequately sampled by the capture-recapture method (Smith, 1974). Species will be determined following Stebbins 1966.

Snakes are active when the temperature is above 55°F. During summer, snakes will be observed during dry periods by the same method used for amphibians. A snake stick will be used to handle rattlesnakes. The snakes will be identified, (Stebbins 1966) recorded on a map by capture location, and released. Since snake species are relatively rare in any habitat, a lack of sightings does not preclude their occurrence.

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Vertebrate Trace Element Study

If the results of the soil and vegetation trace element studies indicate concentrations of toxic elements are occurring on the tracts, tissue samples will be collected in 1976 from deer mice live-trapped in each of the four vegetation sites. Mice will be frozen and sent to a laboratory for whole animal analysis by atomic absorbtion or spark source mass spectrometry to determine levels of arsenic, antimony, cadmium, flourine as flouride, and selenium. Six samples will be collected in each vegetation type to permit statistical comparisons.

Bats

A list of bat species will be compiled. Six mist nets will be erected in the riparian areas from about 8 P.M. to 11 P.M. for five consecutive nights in May 1976 and 9 P.M. to midnight for five consecutive nights in August 1976. Ancillary trapping may include netting some cave entrances and erecting several mist nets in Evacuation Creek. All captured bats will be identified according to Burt and Grossenheider (1964) and released.

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Special Studies

Mule Deer: For effective study of deer on the tracts, the project area was subdivided into six study areas--three riparian and three non-riparian areas--using natural features of the landscape as dividing lines.

The three riparian areas include lands 1 mi on either side of the White River from Hells Hole Canyon to Asphalt Wash. These areas are described as follows:

Area I.	Lands along the White River and 1 mi on either side of the river from Hells Hole Canyon to the bridge at the Ignacio Stage Stop.
Area II.	Lands 1 mi on either side of the river from the White River bridge to Southam Canyon.

Area III. Lands 1 mi on either side of the river from Southam Canyon to the project area boundary west of Asphalt Wash.

The three non-riparian areas include all lands within Tracts U-a and U-b south of the riparian study areas to the outer limits of the 1-mi perimeter (Figure C-1). These areas are described as follows:

Area IV. Lands south of Riparian Area I to the south edge of the project area between Hells Hole Canyon on the east and Evacuation Creek on the west.

Area V. Lands south of Riparian Area II to the south edge of the project area, bounded by Evacuation Creek on the east and the Southam Canyon road on the west.

Area VI. Lands south of Riparian Area III to the south edge of the project area, bounded by Southam Canyon on the east and the project area boundary on the west.

Deer are tranquilized with a Cap-chur gun and succostrin (8 mg to 12 mg dry weight, depending on the estimated body weight of the animal) and fitted with collars containing radio transmitters operating at different frequencies. The signals are monitored on a 24-channel receiver in the Utah DWR telemetry-equipped airplane and in a mobile unit on the ground.

Collared deer are monitored weekly by triangulation from two or more line-of-sight points (Craighead and Craighead 1965). In any telemetry study in rough, rocky, broken topography, a line of sight to the animal is necessary to obtain a valid signal (Seidensticker et al. 1973).

The sightings are used to delineate portions of the area as key mule deer habitat and to establish a pattern of use. Most of the sightings during 1975 were diurnal. Studies in 1976 will emphasize nocturnal sightings to determine movements during a 24-hr period.

An indication of the productivity of a deer population is the ratio of fawns to does (Cowan 1950; Robinette and Olsen 1944). During fall (September to November), observations of deer in the project area are recorded and classified according to three categories--fawns, does, and bucks. During December an aerial count completes deer classification for the year. Since there is no attempt to differentiate between yearling and mature does, the fawn:doe ratio is the total number of fawns and the total number of does, including the relatively unproductive yearling does. Since this method is used in all deer management units in Utah, the data from the project area can be compared with that from other deer herds in northeastern Utah and the rest of the state. In addition, data from subsequent years may be compared with that from the study as a means of monitoring changes in herd productivity over the life of the project.

As an indication of relative hunting pressure and hunting success, hunters are interviewed at a road block placed at the Bonanza Bridge on the first Sunday after opening day of the deer hunting season. Because many of the hunting areas in northeastern Utah are relatively isolated, many of the hunters camp during the opening weekend and return home Sunday; thus, roadblocks at key access points are a good source of data for the first weekend, when a high proportion of animals are taken (Bob Nielson, pers. comm., 1976). In northeastern Utah, roadblocks are set up at access points to every major deer herd unit. In 1975 roadblocks were placed at two access points to Unit 28A, which contains the project area: one at the Bonanza bridge and one at Ouray. Data collected during interviews at the roadblocks include the number of hunters in each party, the number of deer harvested by each party, the location of kills, and the age of kills. The data from the project area are tabulated separately from the rest of the herd unit. These data will be compared with data from other areas and from subsequent years to determine changes in hunting trends and harvest structures in the area.

The browse-utilization study (Cole 1958 and 1963) will consist of reading a number of transects in each vegetation type. The transects will be established in areas of known deer use and will be positioned to sample the variation in the habitat. The species to be read are big sagebrush, greasewood, and

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The browse-utilization study (Cole 1958 and 1963) will consist of reading a number of transects in each vegetation type. The transects will be established in areas of known deer use and will be positioned to sample the variation in the habitat. The species to be read are big sagebrush, greasewood, and rabbitbrush. Each transect consists of 25 plants of the same species at approximately 50-foot intervals. In this procedure the technician reads the first plant and then moves 50 feet along the transect and reads the plant nearest him as the second plant, etc., until 25 plants have been read. Each plant is classified immature, mature, or decadent. The degree of browse availability is determined from the previous winter's snow depth and the plant's height. The percentage of utilization is then determined by a visual estimate of the current year's growth used compared with the growth available.

Since this technique does not discriminate between sheep and deer use, the transects will be read in April, when sheep are the primary users, and in fall, when deer are the users. Many years of this kind of monitoring will establish whether the range is being over used or under used.

One thousand pellet-group plots (circular 1/10 acre) will be staked at 50-foot intervals along 20 transects in the vegetation types. All pellets will be swept from the plots after the last sheep herd has left the tracts in April. Pellet groups on these plots will be counted in fall as an index to deer use in spring and summer. Winter counts will not discriminate between deer and sheep use. The methodology follows Neff, 1968 and Robinette, et. al. 1958.

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Mountain Lion: Professional mountain lion guides using hounds will attempt to capture any mountain lions determined to be in the project area. Utah DWR personnel trained to use capture guns and licensed to use tranquilizing drugs will anesthetize the animals and fit them with radio collars. Immediately following immobilization, a stimulant will be administered to maintain heart and respiration rates, and

released immediately after the collar is attached (adults only). All collared coyotes are monitored weekly by triangulation to determine their territorial and seasonal activities.

All Predators: Data pertaining to predators, including mountain lions, coyotes, bobcats, foxes, badgers, raccoons, and skunks, will be obtained from two scent-station lines operated by the U.S. Fish and Wildlife Service and by aerial and ground observations, trapping records, and inspections of predator kills.

Trapping records of the area filed in the county court house are collected and correlated with field data. In addition, detailed information is taken from the reports of trappers working in the area during the baseline data collection period. When possible, predator kills are inspected to determine the species of predator responsible for the killing.

Raptors: Raptors--hawks, owls, eagles, falcons, and vultures--were studied in spring, summer, fall, and winter. Nesting activity in the project area is determined by on-ground exploration and helicopter reconnaissance of areas where raptors are nesting or displaying territorial nesting

behavior. During the nesting season, each active nest site is observed from a helicopter or by access from the ground to determine the number of young produced during that season.

During each flight, the area was flown in a grid pattern by helicopter. For each sighting, species, age, and location is recorded. Data gathered during this project is supplemental to the regularly scheduled vertebrate program. Data from another study being conducted on the project area by Behle and Perry (1975) is incorporated into the baseline study data base. This study involves travelling regular vehicle routes in the project area and floating the White River to make raptor sightings and to locate raptor nest sites. The data are reduced to provide an estimate of raptor population densities in the project area.

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Waterfowl

Canada geese and other waterfowl on the White River are studied during monthly float trips down the river section within the project area (S-1 to S-11). All waterfowl other than geese are recorded on a species list. All observations of geese are recorded, and when applicable, age and pairing status are included. Only the geese that fly back upstream or that are passed in the canoe are recorded.

The spring census provides data concerning the number of birds; the number of unpaired, or flocked, birds; and the number of paired birds. Paired birds include breeding pairs, non-breeding paired birds, and randomly associated groups of two birds (Folks, pers. comm., 1975). During early summer, the data include the number of juvenile birds; successful breeding pairs; unsuccessful, or non-breeding, birds; flocked birds; unclassified birds (e.g., mixed juveniles and adults not distinguishable as broods); and total number of birds on the project area.

These data are used to estimate population, reproductive success, and the seasons of use in the project area.

the animals will be blindfolded to reduce the possibility of shock. Prior to release, Bicillin will be administered to the animal to minimize infections that may develop from decreased resistance caused by the stress of capture.

Collared lions will be monitored by triangulation twice each week for the first one to two months and subsequently once each week. In addition to telemetry, aerial and ground observations will be conducted to determine the limits of their territory throughout the year.

Bobcats: Bobcats have been observed on the tracts and on the 1-mi perimeter. Any bobcats observed are captured, if possible, and fitted with radio collars. Collared bobcats will be monitored to determine territorial activities and home range.

Bobcats are trapped with a padded clamp type of trap. After capture the animals are blindfolded and wrapped in canvas to reduce shock and to fit the collars. The animals are released immediately after collaring and are monitored by triangulation twice a month. Preferred habitat and use areas within their territories will be determined by plotting all locations on a USGS topographic map with vegetation-map overlays.

Domestic Livestock: Data regarding sheep and cattle are obtained from BLM permits for grazing. Browse utilization will be determined for sheep and deer immediately after the last sheep are driven off of the tracts. Browse utilization for livestock and deer will be determined in riparian areas. The methodology follows Cole, 1963. See deer browse utilization section for a complete discussion and reference of these methods.

Elk, Antelope, and Feral Horses: Since neither elk, antelope, nor feral horses have been observed within the project area, they will not be studied directly; however, during winter aerial observations of deer the proximity of any elk, antelope, or feral horses to the site will be determined.

Coyotes: Coyotes captured on the tracts are fitted with radio transmitters, if possible, and monitored to determine territorial activities and home range.

Coyotes are captured by two different methods. Adult females and their pups are captured at their dens. The adult animal is collared and the pups are ear tagged. A padded clamp type of trap is also used to catch individual animals. Captured animals are blindfolded and wrapped in canvas to reduce the possibility of injury. The animal is

Beaver: Fluctuations in beaver populations on the White River are estimated from cache-count surveys (Utah DWR n.d.). The river is floated from Station S-1 to Station S-11 before the winter freeze. All caches are recorded, although some are probably left from previous years. This method will provide a good index of relative populations from year to year.

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4. TERRESTRIAL INVERTEBRATES

a. Objectives

The primary objective of the terrestrial invertebrates program is to obtain an overview of arthropod diversity by compiling lists of taxa and by listing spatial and temporal distribution and density of the more abundant and important species. A secondary objective is to determine species food habits from general observations and from literature review.

b. Methodology

Invertebrates are sampled quantitatively by "sweeping" and Burlese funnels. In the sweeping method a net with a 12-in. rim and a bag made of nylon organdy is used to sweep at monthly intervals the more abundant and significant plant

species for resident or visiting arthropods. One hundred net strokes are made per plant species per month at three locations (the White River bridge crossing, Evacuation Creek highway crossing, and the roadside about 200 m northeast of air-monitoring Station A-11). With a sweep of approximately 1/2 cu ft of vegetation, it is possible to estimate populations by correlating the counts with the known densities and sizes of the plants involved. The arthropods in the material accumulated from 100 net strokes are stunned in a gallon-sized cyanide can, placed in a paper bag, labelled, and placed in the cyanide can until dead. In the lab the coarse plant debris is removed, and at a later date the arthropods are sorted from the finer debris and stored until the validation collection is complete enough for sorting (to species) and counting.

Litter and moss samples are collected and the microinvertebrates are extracted from them by Berlese funnels. The samples are collected in spring, before the litter dries and after prolonged rains. The various invertebrates are counted from standard volumes of collected material.

Several methods are used for qualitative sampling. In the sweeping method the sweepings from quantitative samples are searched for additions to the validation collection. Sweepings additional to the quantitative sweepings of various plant species are made with an indeterminant number

of strokes, and any new arthropod species from each plant species are removed from samples for mounting. The additional sweeping is done primarily when sampling from separate plant species is impractical--for example, at the marshy zone near the White River bridge. The insect net is used to catch arthropods on flowers, in flight, on the ground, etc. In a method known as "beating," a 1-m^2 canvas sheet is held rigid by a crossframe positioned under branches of shrubs or trees and a club is used to dislodge the arthropods. This method is useful during daytime for catching slow-moving insects on vegetation in areas difficult to sweep and for catching species that feed on aboveground plant parts at night. This method is more efficient at night with two individuals, one holding a lantern and the other beating the vegetation. Arthropods are collected in hidden areas such as under bark, under stones, logs, droppings, in carcasses, in fresh manure, in spaces between rocks, etc. Lights and lighttraps are used to collect adult insects from spring through fall. Used at night, this method involves ultraviolet lighttraps and ultraviolet lights reflected on sheets of white cloth. Another method of collecting adult insects from spring through fall is with four malaise traps placed opportunistically over expected paths of flying insects. Once the insect enters the trap it cannot get out, and it is eventually funnelled into a jar of poison. Certain

insects can be collected in traps baited with decaying meat and excrement, with "fly traps" used over them to trap flying insects.

All captured insects are placed in kill jars containing potassium cyanide. Once the specimens are dead they are removed from the jars, sorted, and mounted on pins and placed in insect boxes. Each pin bears a label that includes the place of capture, date, and limited ecological data, such as the host plant. The specimens are maintained at Utah State University, Logan. Utah State University makes the validation determinations to the extent possible; many of the specimens are sent to specialists in the United States and Canada for additional determinations.

5. MICROBIOLOGY

a. Objectives

The objectives of the microbiology study are to estimate the number of microorganisms and to measure their biochemical activities in the soils. Their activities are the prime and, for all practical purposes, the sole factor in detritus and litter decomposition and mineral cycling.

b. Methodology

There are four sampling stations, one in each of the four vegetation types (Figure C-1). An auger is used to collect soil samples bimonthly at each station at depths of 0-3 cm, 5-20 cm, and 40-50 cm. At the juniper and sagebrush-greasewood stations, samples are collected from beneath the canopy and from the plant interstices. In addition, a surface-litter sample is taken from beneath the juniper canopy.

Each soil sample is placed in a sterile plastic bag for transportation to the laboratory, where each sample is ground or particles larger than 3 mm in diameter are removed. Each sample is then stored at 4°C until examined. The parameters measured and the methods used are presented in the following subsections.

Statistical methods are not applicable to the microorganism study because a microbiologist considers population variations

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b. Methodology

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Each soil sample is placed in a sterile plastic bag for transportation to the laboratory, where each sample is ground or particles larger than 1 mm in diameter are removed. Each sample is then stored at 4°C until examined. The parameters measured and the methods used are presented in the following subsections.

Statistical methods are not applicable to the microorganism study because a microbiologist considers population variations within an order of magnitude an indication of a relatively constant population size which could result in a standard deviation twice as large as the mean of the population.

The results of the first and second year of the baseline study will be compared.

Numbers of Microorganisms

The number of aerobic and anaerobic bacteria and fungi are determined according to Allen 1957.

Dehydrogenase Activity

Dehydrogenase activity in soil is measured to obtain correlative information about the biological activities of microbial populations in soil rather than about the enzyme itself. Fertile, cultivated soils exhibit high dehydrogenase activity, whereas saline or high pH soils exhibit almost no activity. The determination of dehydrogenase activity is based on the ability of the soil to reduce triphenyltetrazolium chloride to the respective formazan (Casida et al. 1964). Hence, the rate of formazan formation is indicative of total biological activity.

Proteolytic Activity

The hydrolysis of proteins by soil microorganisms is necessary in the nitrogen cycle of soils. The amount of proteolytic activity, therefore, indicates the ability of a particular

soil to hydrolyze protein. Proteolytic activity is related to moisture content and varies during the vegetative period. In addition, activity also decreases with depth in the soil. Proteolytic activity is determined according to Hoffmann and Teicher 1957.

Respiration

Measuring the rate of CO_2 production (respiration) in soil is an indirect method of determining a soil's biological activity and organic matter decomposition rates. Respiration is determined according to Elkan and Moore 1962.

Water Potential and Water Content

The negative water potential, expressed in bars of atmospheric pressure, is a useful method of relating soil moistures to activities occurring within the soil by analyzing seasonal changes in biological activities where moisture is always a factor. A Wescor psychrometer is used for these measurements (Brown and Van Haveren 1972).

Nitrification Potential

Nitrification potential is measured by the perfusion method, and the perfusates are analyzed for ammonium, nitrite, and nitrate (Skujins 1973). In this procedure the technician modifies the soil condition to maximize ammonium oxidation by the nitrifying populations.

ATP Concentration

Adenosine triphosphate (ATP) is a ubiquitous compound present in all living organisms. Several million bacteria, in addition to fungi and streptomycetes, contribute to the total ATP concentration in soil. It has been established that the average amount of ATP in a bacterial cell is 5×10^{-11} ug. Since ATP represents a universal form of energy available to any cell, it represents a measure of biological activity in soil. The methodology follows Skujins 1975.

Nitrate Values

The decomposition of proteins and other nitrogenous organic substances causes ammonia to form in the soil. Under favorable conditions, ammonia is rapidly oxidized to nitrite and then to nitrate. Most of the nitrate is assimilated by plants or denitrified (lost to the atmosphere as N_2 gas). Thus, the concentration of nitrate indicates the nitrogen available to plants and the net rate results of nitrification and dentrification. The methodology follows Skujins 1972.

Organic Carbon and Nitrogen

Soil organic carbon and nitrogen values represent an accumulation of partially decayed and partially synthesized plant and animal residues, essentially the sole source of soil nitrogen. Decomposition rates are best expressed as a carbon:nitrogen ratio. The methodology follows Skujins 1972.

Nitrogen Fixation

Nitrogen fixation is the process by which free atmospheric nitrogen is converted to ammonia and nitrates by microorganisms. This fixed nitrogen is then available for plant use. Expressed as g of N fixed per hectare per day, nitrogen fixation (N_2) is determined according to Rychert and Skujins 1974.

Total Ammonium Nitrogen

The total ammonium nitrogen values measured in ug per gram of soil is another expression of microbial activity and is a step in the nitrogen cycle. Total ammonium nitrogen determinations follow the methodology of Skujins 1972.

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6. AQUATIC BIOLOGY

a. Objectives

Aquatic systems are being studied to document conditions in the White River and Evacuation Creek. The study was designed to determine the composition, abundance, and temporal and spatial distribution of aquatic macrophytes (vascular plants), periphyton, plankton, macroinvertebrates, and fish. A secondary objective is to collect data by standard methods that can be repeated. This is necessary because of the large number of samples needed to produce statistically reliable data (Needham and Usinger 1956).

b. Methodology

The methods of sampling and statistical analyses are those of the EPA, USGS, public health agencies, and other groups involved in applied aquatic biology. These methods are discussed by APHA (1971), Usinger (1971), Slack et al. (1973), Weber (1973), Welch (1948), and Lagler (1956).

Because natural aquatic populations tend to clump, or occur in patchy distribution, there are often considerable differences between samples taken from apparently similar stream sections or from different sections of the same riffle; therefore, samples are taken from the same location as much as possible.

There are five sampling stations on the White River and one on Evacuation Creek (Figure C-1). The stations were selected on the basis of accessibility, proximity to water quality monitoring stations, and stream characteristics. Approximately 1,000 ft of stream is sampled at each station, which usually includes a variety of stream types (i.e., pool, glide, riffle, eddy, etc.) and generally represents conditions throughout the river section being studied.

During the first year of the study it was found that a complete set of quantitative samples can be taken only at the following times:

(1) after the ice thaws and before the beginning of mountain snowmelt runoff, usually April.

(2) after mountain snowmelt runoff has passed and when discharge rates and turbidity are low, usually August

(3) between December and March, preferably February

During these periods the water level is generally low, organisms are somewhat concentrated, and specific sampling locations are accessible. At each of these times, certain aspects of the stream ecology can be evaluated. Additional samples are collected opportunistically to allow the development of a continuum that would show conditions at any point in an annual cycle. The sampling equipment was selected for

its functional utility and potential to sample adequately different sectors of the aquatic biota. In spite of recent advances in equipment design, the samplers available are still inadequate. Lattin (1971) points out that "All existing techniques are inadequate or impractical for statistical analysis but in spite of obvious shortcomings, they are the best we have." Most investigators supplement commercial equipment with homemade devices, which are often effective in supplying data that could not be collected by conventional devices.

Two microscopes are used for sorting and identifying organisms. The dissecting scope is a Bausch and Lomb 7-30X stereozoom model binocular microscope that provides three-dimensional observation. An auxiliary 2X lens is used to magnify up to 60X, enough for all but algae and the most difficult invertebrates. The compound scope--a Zeiss phase contrast model with four lenses that can magnify from 32X to 1000X--is used to identify diatoms, other algae, and some insects that can be identified only by minute characteristics of the organism.

The samples are preserved in a mixture of 10 percent formalin, 2 percent glacial acetic acid, and 88 percent water by volume. The preservative works well on invertebrates and preserves algae with a minimum of discoloration or distortion.

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Periphyton

Periphyton is defined as a community of microorganisms associated with the surfaces of submerged objects (A.P.H.A. 1971.) The community usually consists of diatoms and other small algae, rotifers, protozoans, etc. Early efforts to collect periphyton with Dendy samplers and various floating artificial substrates were unsuccessful. A more successful method--wooden floats to deploy the artificial substrates--was finally developed. The floats are made from a piece of pine wood measuring approximately 5 cm x 25 cm x 38 cm (2 in. x 10 in. x 15 in.) fitted with 3 metal straps each holding a 5.1 cm x 12.7 cm (2 in. x 5 in.) mylar strip.

The floats are anchored in streams near surface water monitoring stations, and periphyton is allowed to accumulate for four weeks. The strips are then removed and placed in an empty vial provided by the USGS. No preservative is used. The bottles are immediately placed in a paper bag, stored in an ice chest, and taken to the field lab, where they are frozen. When all samples have been collected, two samples from each station are packed in dry ice and shipped by air freight to the USGS laboratory at Doraville, Ga., where they are kept in the dark and frozen until analyzed. The USGS is analyzing the samples for productivity using the chlorophyll extraction methods of Slack et al. (1973). Productivity is expressed as the ratio of biomass (g/m^2) to chlorophyll

pigments a and b (mg/m^2).

One sample strip from each periphyton collection is preserved in formalin. Accumulated growth on the sample strip is scraped into the preservative with a "rubber policeman," and the sample jar is closed and agitated violently to disperse algal cells into the preservative. Aliquots (sub-samples) are placed in a Sedgwick-Rafter cell, and algal cells are counted in accordance with Standard Methods, SEC. 601D (APHA 1971). Standard keys are used for identifying the algae (Prescott 1970; Patrick and Reimer 1966; Weber 1971, etc.).

Plankton

A hand-held plankton net is used for collecting and straining qualitative plankton samples occasionally for capturing minnows, insects, etc. The sampler consists of a 1.5-m (4.9-ft) handle attached to a heavy wire (#9) ring 0.23 m (9 in.) in diameter with a net with an aperture size of 0.086 mm (157 meshes per in.) suspended from the wire ring. Duplicate qualitative plankton samples are taken by suspending the net in the current at mid-depth for approximately 10 sec.

The samples are preserved in formalin and agitated by blowing into the container through a pipette placed against the material settled on the bottom. This suspends much of the

material trapped in the sand and sediment, which constitutes the bulk of the sample. In a few seconds most of the sand settles on the bottom of the container, and a sample is poured into a petri dish. Subsamples of this portion are placed on a slide for examination on the compound microscope. Organisms are identified to the lowest practical taxon, and a relative-abundance designation is assigned to each group.

A Wildlife Supply Company No. 1120 sampler is used for taking triplicate quantitative plankton samples. The device consists of a plastic tube closed by rubber cups over the ends. The rubber ends are locked open and the sampler is held parallel to the current and lowered to mid-depth. When the release is activated, an elastic cord snaps the rubber cups into place and traps a 2,200-ml (2.3-qt) sample. The material is then strained through a #16-mesh plankton net and preserved in vials containing approximately 50 ml of preservative.

The samples are evaluated using a Sedgwick-Rafter counting cell. A pipette is used to blow air against the bottom of the vial to suspend the material uniformly and to withdraw exactly 1 ml of the concentrate for placement in the counting cell. When plankton is abundant, the material must be diluted for counting. If the cover fails to rotate, distilled water is added until it does.

The cell is then placed on the compound microscope and all

organisms within a 1-mm transect across the cell are counted. The cell is 50 mm long and 1 mm deep; therefore, each strip counted constitutes 50 cubic mm. Four strips are counted on each of three cells. Calculations are performed in accordance with A.P.H.A. (1971) and adjusted to reflect the cells per ml in the original 2200-ml collection. One of the triplicate samples is used for quantitative analysis, one is used for species identification, and one is stored for possible future use.

Aquatic Macrophytes

No significant populations of aquatic macrophytes occur within the study area.

Aquatic Invertebrates

A Surber sampler is used to collect bottom invertebrates from shallow rapids and riffles. Depending on the velocity of the current, the sampler can be used in water up to 0.6 m (2 ft) deep. It is the most effective in water less than 0.3 m (1 ft) deep. The sampler consists of a 0.3 m^2 (1 ft^2) hinged brass frame with a mesh bag attached to one wing of the frame. The other wing outlines the area to be sampled. The sampler is placed against the bottom in the open position and the bag is allowed to billow with the current. The operator vigorously disturbs the stream bottom area within the brass frame and rinses the stones, stirring underlying

material with the fingers or a probe (APHA, 1971). This dislodges invertebrates from the bottom materials, and the current conveys them into the mesh bag. When the collection is complete, the sample is removed and preserved in formalin. Five to seven samples are taken at each river station, except at Station F-1, where the sampler is often ineffective because of the deep, swift current. Where possible the samples are taken in a transect, often on the inside of a bend where shallow riffles extend well out into the river.

The collections are examined in the field laboratory at Bonanza, Utah. Invertebrates are separated from the stones and debris and the material is placed in Petri dishes and sorted under the dissecting microscope. A variety of keys are used to sort the organisms, mostly insects and worms, to the lowest practical taxon (see references cited).

The data from each sample are used to calculate the Shannon-Weaver diversity index according to $\bar{d}=\frac{C}{N}(N \log_{10} N-\Sigma n_i \log_{10} n_i)$

where $\bar{d}$ = diversity index
C = 3.32 which converts $\log_2$ to $\log_{10}$
N = Total number of individuals
n_i = Total individuals of ith species.

Higher species diversities usually indicate ecosystems which are in equilibrium, i.e., more stable. The findings are recorded on lab worksheets for inclusion in reports. After examination, most of the organisms are preserved at the laboratory. Identification of most species has been confirmed by other workers.

The Ekman dredge, a stainless steel device that samples an area of 0.023 m^2 (36 $in.^2$), is used to collect invertebrates in soft bottom material. The dredge is locked open and lowered to the bottom. As it contacts the bottom, the release mechanism is activated and strong springs snap the jaws to the closed position. The dredge is removed from the water and its contents emptied into a wash bucket. resembling a regular plastic bucket but of heavy construction with a bottom of standard U.S. #30 screen. Organisms that do not escape through this screen are defined as macroinvertebrates (Weber 1973). The mesh aperture of the screen is 0.595 mm (28 meshes per inch). Material from the sampler is poured into the bucket and swirled in the water. The sand, silt, detritus, and microorganisms escape through the screen and simplify the sorting and identification process. The samples are stored in preservative. In the laboratory, the samples are placed in Petri dishes, and organisms are sorted from the debris under the dissecting microscope. Most of the organisms in these samples are dipteran larvae or worms. They are often small (less than 2 mm) and must be identified by dissection and observation at high magnification with a compound microscope.

The Ekman dredge is very effective for collecting samples from silty areas, but it is limited in that the sample can be lost if sticks or stones in the bottom material prevent the jaws from closing. In areas with a deep, strong current, The Ekman dredge, a stainless steel device that samples an area of 0.023 m^2 (36 in.^{2}), is used to collect invertebrates in soft bottom material. The dredge is locked open and lowered to the bottom. As it contacts the bottom, the release mechanism is activated and strong springs snap the jaws to the closed position. The dredge is removed from the water and its contents emptied into a wash bucket. resembling a regular plastic bucket but of heavy construction with a bottom of standard U.S. #30 screen. Organisms that do not escape through this screen are defined as macroinvertebrates (Weber 1973). The mesh aperture of the screen is 0.595 mm (28 meshes per inch). Material from the sampler is poured into the bucket and swirled in the water. The sand, silt, detritus, and microorganisms escape through the screen and simplify the sorting and identification process. The samples are stored in preservative. In the laboratory, the samples are placed in Petri dishes, and organisms are sorted from the debris under the dissecting microscope. Most of the organisms in these samples are dipteran larvae or worms. They are often small (less than 2 mm) and must be identified by dissection and observation at high magnification with a compound microscope.

The Ekman dredge is very effective for collecting samples from silty areas, but it is limited in that the sample can be lost if sticks or stones in the bottom material prevent the jaws from closing. In areas with a deep, strong current, it is easy to tip or tumble the dredge. Lattin (1971) and Welch (1948) discuss the sampler and its use.

A square section of screen with a wooden handle on each side and a plankton net are used to collect qualitative samples of aquatic insects that might be missed in quantitative samplers. It is generally used in areas too deep or too swift for Surber sampling. The screen is placed against the streambed and held while the operator vigorously disturbs the bottom materials with his feet (Lattin 1971). Invertebrates are dislodged from the bottom and captured in the screen. A plankton net is used primarily for collecting water treaders, water striders, and other surface-dwelling insects.

The Fishery

Fish are collected at eight stations spaced along the White River between Hell's Hole Canyon, approximately 2.4 km (1.5 mi) upstream of Tract U-b, and the confluence with the Green River, near Ouray, Utah. Fish are collected mainly by electro-fishing with an Onan 220-volt direct current shocker and 500 ft of cord. Because shocking upstream (against the current) was not feasible with 500 ft of cord pulling against the field technicians, shocking is done downstream. The collectors are downstream of the shocker and lose no more fish than are lost shocking upstream. Shocking is difficult in the deep, swift water in the middle of the stream, and therefore most of the fish are collected from near the stream banks.

Shocking is conducted by playing out 500 ft of cord initially upstream from the generator. At each station the crew moves downstream to the generator and continues on down the river another 500 ft. The crew then crosses to the other side of the river and repeats the operation, shocking 2,000 ft (610 m) of shoreline at each station.

The captured fish are preserved in formalin, and DWR personnel identify and count the fish and forward them to Brigham Young University (Bauman 1975). These collections are examined to determine the representative size of species and their condition.

Seines and minnow traps and occasionally a section of screen are used to catch fish for additional studies. The minnow traps have been generally ineffective, but seines are effective in eddies, backwaters, and residual pools that remain after spring flooding. The captured fish are identified, marked by fin clipping, and released. When seining efforts are productive, recaptures are attempted the following day. Occasionally, specimens are retained for laboratory confirmation of identification and for study of length:weight ratios.

Statistical Applications

Several factors can reduce the validity of statistical analyses in studies of stream ecology. The most significant is the different habitats used by one population, which can lead to variations in samples. Stratified sampling will give better results, but extremely large samples are usually required for high confidence levels.

Needham and Usinger (1956) examined stratified sampling with regard to invertebrates in one riffle of Prosser Creek, California. The riffle was shallow and the substrate and current conditions generally singular throughout. They used a Surber sampler to take 100 samples from a grid. Their analyses indicated that 73 samples were required for 95 percent confidence levels. This study involved only one, uniform habitat; when a variety of habitats are involved--

pools, riffles, glides, and different substrates (mud, sand, rubble, etc.)--a much larger number of samples is required. Considering these restrictions, statistical analysis will be applied to the following:

plankton--cell counts

periphyton--cell counts, biomass, chlorophylls a and b

macroinvertebrates--organism numbers.

The mean, variance, standard deviation, standard error of mean, confidence limit of mean, and number of samples required to estimate within 25 percent of the true mean with a 90 percent level of statistical confidence will be determined.

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7. ECOLOGICAL INTERRELATIONSHIPS

A preliminary "word model" of the ecological interrelationships, including migratory patterns of birds, mammals, fish and including plant-animal relationships, will appear in the first-year environmental baseline report. Relationships of flora and fauna to abiotic components of the tracts will also be included. The "word model" for the final report will be an elaboration of the first year's "word model" and will be based on two years of data and a better understanding of the physical and biological functioning on the tracts. Statistical comparisions will be made among abiotic and biotic factors when appropriate and possible.